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*Mécanique Céleste: Observations sur la Comparaison établie par M. Delaunay entre les Expressions des Coordonnées de la Lune déduites de sa Théorie avec celles qui avaient été obtenues antérieurement.** Par M. G. de Pontécoulant.

Rien sans doute ne saurait être plus utile au perfectionnement de la théorie de la Lune que la comparaison des expressions, obtenues par des méthodes différentes, des trois coordonnées qui fixent à chaque instant la position de cet astre, et qui doivent servir à la construction des tables lunaires. Aussi M. Delaunay a fait, sous ce rapport, un travail très recommandable lorsqu'il a dernièrement comparé les résultats obtenus par M. Plana dans sa Théorie de la Lune, à ceux qu'il a déduits lui-même de la méthode qu'il a suivie pour arriver au même but; mais comme l'auteur n'a publié jusqu'à présent que l'exposition de la méthode, et que le second volume de son ouvrage, qui doit contenir les applications numériques, n'a pas encore paru, il est tout-à-fait impossible, au moins quant à présent, de découvrir les véritables causes qui ont produit les différences qu'on remarque entre quelques uns de ses résultats et ceux de M. Plana, et de décider d'une manière certaine de quel coté est l'erreur, puisque d'après le mode de comparaison adopté par M. Delaunay, ces résultats devraient être parfaitement identiques. Cependant il m'a paru d'après la seule inspection des tableaux de M. Delaunay que plusieurs des résultats qu'il présente peuvent être avec raison

* Voir les *Comptes Rendus* de l'Académie des Sciences; 1862, 1^er^ Semestre. (T. liv. Nos. 15, 16, 17, et 18.)

regardés comme entachés d'inéxactitude; et c'est à provoquer sur ce point une utile discussion entre les géomètres qui se sont occupés de la théorie de la Lune, pour arriver enfin à des formules parfaitement correctes, telles qu'on doit les espérer de l'état actuel de la science, que cette note est spécialement destinée.

J'examinerai successivement les expressions des trois coordonnées de la Lune, *la longitude, la latitude, et la valeur inverse du rayon vecteur*, en suivant l'ordre adopté par M. Delaunay, en négligeant d'abord comme il l'a fait les termes d'un ordre supérieur au 7e; nous négligerons également pour abréger le travail, à moins de quelques circonstances particulières, les termes indépendants de la quantité très petite m, ou multipliés par une puissance de cette quantité inférieure à la 3e, parceque ces termes étant indépendants de la force perturbatrice, ou ne dépendant en général que de la première puissance de cette force, il sera toujours assez facile de les vérifier et de reconnaître par conséquent la cause des anomalies qu'on remarquerait entre les résultats trouvés à cet égard par les différents auteurs. J'omettrai de même, pour abréger autant que possible cette note, les termes où les résultats de M. Delaunay, tout en s'éloignant de ceux de M. Plana, concordent avec ceux obtenus antérieurement par M. Lubbock, ou par moi, puisque les corrections qu'ils indiquent dans les valeurs données par M. Plana, peuvent être regardées désormais comme acquises à la science.

Dans les tableaux suivants je présenterai les résultats obtenus par M. Plana tels qu'ils sont donnés dans son ouvrage, et sans leur faire subir aucune transformation, et je ramenerai au contraire les résultats de M. Delaunay que je me proposerai de leur comparer, à ce qu'ils devraient être en adoptant pour l'excentricité e de l'orbe lunaire et son inclinaison γ à l'écliptique, les valeurs que M. Plana leur attribue; il m'a semblé que les différences des résultats en ressortiraient mieux, puisque ce sont en définitive les résultats de M. Plana qui doivent servir de terme de comparaison.

Dans une colonne particulière je présenterai en regard des résultats précédents, ceux que j'ai obtenus moi-même dans ma théorie des mouvements lunaires (*Théorie Analytique du Système du Monde*, t. iv.), et j'ajouterai au pied les observations succinctes qui peuvent résulter de cette double comparaison.

Les inégalités dont dépendent les différents termes que nous aurons à examiner, seront indiquées par leurs arguments dans lesquels :

D *représente la longitude moyenne de la Lune moins celle du Soleil.*
F *la longitude moyenne de la Lune moins celle du Nœud.*
l *l'anomalie moyenne de la Lune.*
l' *l'anomalie moyenne du Soleil.*

Longitude.

Arguments.	Termes de Plana.	Termes de Delaunay.	Théorie Analytique.
l'	$-\frac{39522017}{6144} m^4 e^2 e'$	$-\frac{66621857}{6144} m^4 e^2 e'$	$-\frac{39522017}{6144} m^4 e^2 e'$ (a)
	$+\frac{3257665}{576} m^6 e'$	$+\frac{3253129}{576} m^6 e'$	$+\frac{3257665}{576} m^6 e'$ (b) A*
$l-l'$	$+\frac{8548531}{6144} m^4 e e'$	$+\frac{2814537}{2048} m^4 e e'$	$+\frac{2844993}{2048} m^4 e e'$ (c) A*
	$+\frac{307373383}{36864} m^5 e e'$	$+\frac{103086725}{12288} m^5 e e'$	$+\frac{307187071}{36864} m^5 e e'$
$l+l'$	$-\frac{4173895}{6144} m^4 e e'$	$-\frac{2714815}{6144} m^4 e e'$	$-\frac{2806183}{6144} m^4 e e'$ (d)
	$-\frac{19962409}{9216} m^5 e e'$	$-\frac{42301831}{18432} m^5 e e'$	$-\frac{19962409}{9216} m^5 e e'$ (e)
$l-2l'$	$-\frac{489}{128} m e^3 e'^2$	$+\frac{153}{128} m e^3 e'^2$	$-\frac{1017}{256} m e^3 e'^2$ (f)
$2l$	$-\frac{6221}{192} m^2 e^4$	$-\frac{29543}{1536} m^2 e^4$	$-\frac{78109}{4608} m^2 e^4$
	$-\frac{567}{16} m^2 e^2 e'^2$	$-\frac{4089}{128} m^2 e^2 e'^2$	$-\frac{3809}{128} m^2 e^2 e'^2$
	$-\frac{5597}{64} m^4 e^2$	$-\frac{11319}{128} m^4 e^2$	$-\frac{5597}{64} m^4 e^2$ (g)
$2F-l$	$+\frac{21387}{2048} m^3 e \gamma^2$	$-\frac{1797}{2048} m^3 e \gamma^2$	$+\frac{2867}{2048} m^3 e \gamma^2$ (h)
$2D$	$-\frac{904829}{9216} m^3 e^4$	$-\frac{343199}{3072} m^3 e^4$	$-\frac{118199}{3072} m^3 e^4$
	$-\frac{761227}{6144} m^3 e^2 e'^2$	$-\frac{293497}{2048} m^3 e^2 e'^2$	$-\frac{264025}{2048} m^3 e^2 e'^2$
	$+\frac{144641579}{294912} m^5 e^2$	$+\frac{142735019}{294912} m^5 e^2$	$+\frac{143944619}{294912} m^5 e^2$
	$-\frac{70043}{768} m^5 e'^2$	$-\frac{61969}{864} m^5 e'^2$	$-\frac{91129}{864} m^5 e'^2$
$2D-l'$	$+\frac{7220939}{4096} m^4 e^2 e'$	$+\frac{7254731}{4096} m^4 e^2 e'$	$+\frac{7273931}{4096} m^4 e^2 e'$

* Les termes marqués d'un A ont été verifiées par M. Adams.

Arguments.	Termes de Plana.	Termes de Delaunay.	Théorie Analytique.
	$-\frac{245}{32}\ m\,e^4\,e'$	$-\frac{105}{32}\ m\,e^4\,e'$	$-\frac{35}{64}\ m\,e^4\,e'$
$2\,D+l'$	$+\frac{14201441}{4096}\ m^4\,e^2\,e'$	$+\frac{44611649}{36864}\ m^4\,e^2\,e'$	$+\frac{4791425}{4096}\ m^4\,e^2\,e'$
	$+\frac{105}{32}\ m\,e^4\,e'$	$+\frac{45}{32}\ m\,e^4\,e'$	$+\frac{15}{64}\ m\,e^4\,e'$
$2\,D+l$	$+\frac{940855}{82944}\ m^6\,e$	$+\frac{1863229}{82944}\ m^6\,e$	$+\frac{1228925}{41472}\ m^6\,e$
	$-\frac{967447}{2304}\ m^4\,e\,e'^2$	$-\frac{963415}{2304}\ m^4\,e\,e'^2$	$-\frac{957907}{2304}\ m^4\,e\,e'^2$
	$+\frac{2354603}{8192}\ m^4\,e^3$	$+\frac{5433089}{24576}\ m^4\,e^3$	$+\frac{6040589}{24576}\ m^4\,e^3$
$2\,D-l$	$+\frac{3496767841}{2654208}\ m^6\,e$	$+\frac{3514035745}{2654208}\ m^6\,e$	$+\frac{3464046433}{2654208}\ m^6\,e$ (i)
	$+\frac{127960397}{221184}\ m^5\,e$	$+\frac{127571597}{221184}\ m^5\,e$	$+\frac{127960397}{221184}\ m^5\,e$ (j)
	$+\frac{36126953}{9216}\ m^4\,e\,e'^2$	$+\frac{37031581}{9216}\ m^4\,e\,e'^2$	$+\frac{37134073}{9216}\ m^4\,e\,e'^2$
	$-\frac{326681}{1536}\ m^3\,e\,e'^2$	$-\frac{322081}{1536}\ m^3\,e\,e'^2$	$-\frac{326617}{1536}\ m^3\,e\,e'^2$ (k)
	$-\frac{14428681}{24576}\ m^4\,e^3$	$-\frac{8805001}{24576}\ m^4\,e^3$	$-\frac{10219551}{24576}\ m^4\,e^3$
	$-\frac{827639}{18432}\ m^3\,e^3$	$-\frac{91071}{2048}\ m^3\,e^3$	$-\frac{64221}{2048}\ m^3\,e^3$
$2\,D-l-l'$	$+\frac{1211197}{8192}\ m^5\,e\,e'$	$+\frac{1200185}{8192}\ m^5\,e\,e'$	$+\frac{1202189}{8192}\ m^5\,e\,e'$
$2\,D-l-2\,l'$	$+\frac{219639709}{73728}\ m^4\,e\,e'^2$	$+\frac{218629693}{73728}\ m^4\,e\,e'^2$	$+\frac{219825901}{73728}\ m^4\,e\,e'^2$ (l)
$2\,D-l+2\,l'$	$-\frac{46669}{128}\ m^4\,e\,e'^2$	$-\frac{46831}{128}\ m^4\,e\,e'^2$	$-\frac{23417}{64}\ m^4\,e\,e'^2$
$2\,D-2\,l$	$+\frac{2166605291}{884736}\ m^5\,e^2$	$+\frac{1966421891}{884736}\ m^5\,e^2$	$+\frac{2117652131}{884736}\ m^5\,e^2$
$2\,D-l+l'$	$+\frac{2827212637}{221184}\ m^6\,e\,e'$	$+\frac{2745937561}{221184}\ m^6\,e\,e'$	$+\frac{2827212637}{221184}\ m^6\,e\,e'$ (m)
$2\,D-2\,F$	$-\frac{168653}{18432}\ m^4\,\gamma^2$	$-\frac{110333}{18432}\ m^4\,\gamma^2$	$-\frac{110333}{18432}\ m^4\,\gamma^2$ (n)

Arguments.	Termes de Plana.	Termes de Delaunay.	Théorie Analytique.
$4\,D - l + l'$	$-\frac{3547567}{8192}\, m^5\, e\, e'$	$-\frac{241903}{8192}\, m^5\, e\, e'$	$-\frac{363727}{8192}\, m^5\, e\, e'$
D	$-\frac{1553407}{1024}\, m^5 \frac{a}{a'}$	$-\frac{2357119}{1536}\, m^5 \frac{a}{a'}$	$-\frac{4628333}{3072}\, m^5 \frac{a}{a'}$
$D + l'$	$-\frac{124805}{768}\, m^3 \frac{a}{a'}\, e'$	$-\frac{123365}{768}\, m^3 \frac{a}{a'}\, e'$	$-\frac{128485}{768}\, m^3 \frac{a}{a'}\, e'$
$D - l$	$-\frac{156147}{1024}\, m^3 \frac{a}{a'}\, e$	$-\frac{155267}{1024}\, m^3 \frac{a}{a'}\, e$	$-\frac{155267}{1024}\, m^3 \frac{a}{a'}\, e$ (o)
	$-\frac{14427729}{16384}\, m^4 \frac{a}{a'}\, e$	$-\frac{14382081}{16384}\, m^4 \frac{a}{a'}\, e$	$-\frac{14382081}{16384}\, m^4 \frac{a}{a'}\, e$ (o)

Observations.

(a) Notre valeur s'accorde avec celle de M. Plana, celle de M. Delaunay parait fautive.

(b) Idem.

(c) Notre valeur revue par M. Adams, ne laisse aucun doute sur son exactitude.

(d) Notre valeur employée dans le calcul du terme suivant qui s'accorde avec celui de M. Plana, est necessairement exacte.

(e) Notre valeur coincide avec celle de M. Plana.

(f) La valeur de M. Delaunay parait à la fois inexacte et de signe contraire à ce qu'elle devrait être.

(g) Il y a soupçon d'erreur dans les calculs de M. Delaunay puisque nous nous accordons avec M. Plana.

(h) On trouve le détail du calcul de ce terme assez difficile dans les *Comptes Rendus* de l'Acad. 1842.

(i) Comme ce terme dépend du terme en $m^5 e$ qui est inexact dans les calculs de M. Delaunay on ne saurait s'étonner de la différence qui existe entre nos valeurs.

(j) Nous nous accordons avec M. Plana.

(k) Notre terme employé dans le calcul d'autres quantités a donné des résultats exacts, ce qui le vérifie.

(l) Il entre dans le calcul de ce terme des quantités qui ne sont pas données par M. Plana, ce qui peut causer la différence qu'on remarque dans nos valeurs.

(m) L'accord de notre résultat avec celui de M. Plana parait prouver suffisamment que la valeur de M. Delaunay est fautive.

(n) La révision de nos calculs nous a amenés à constater l'exactitude de la valeur donnée par M. Delaunay.

(o) La révision de nos calculs nous a amenés à un accord parfait avec M. Delaunay.

*Latitude.**

Arguments.	Termes de Plana.	Termes de Delaunay.	Théorie Analytique.
$F - l$	$-\frac{45611}{2048} m^4 e \gamma$	$-\frac{46587}{2048} m^4 e \gamma$	$-\frac{45611}{2048} m^4 e \gamma$ (a)
$F + l$	$-\frac{2679}{128} m^4 e \gamma$	$-\frac{2739}{128} m^4 e \gamma$	$-\frac{2679}{128} m^4 e \gamma$ (a)
	$-\frac{1356205}{12288} m^5 e \gamma$	$-\frac{710431}{6144} m^5 e \gamma$	$-\frac{710431}{6144} m^5 e \gamma$ (b)
$2D - F$	$-\frac{4548169}{442368} m^5 \gamma$	$-\frac{4548169}{442368} m^5 \gamma$	$-\frac{4548169}{442368} m^5 \gamma$ (c)
$2D + F$	$+\frac{134555}{2048} m^3 e^2 \gamma$	$+\frac{126875}{2048} m^3 e^2 \gamma$	$+\frac{126875}{2048} m^3 e^2 \gamma$ (d)
$2D - F - l'$	$+\frac{25493}{512} m^4 e' \gamma$	$+\frac{158057}{4096} m^4 e' \gamma$	$+\frac{158953}{4096} m^4 e' \gamma$
$2D - F + l'$	$+\frac{24337}{4608} m^4 e' \gamma$	$+\frac{131363}{36864} m^4 e' \gamma$	$+\frac{134927}{36864} m^4 e' \gamma$
$2D - F - 2l$	$+\frac{435649}{6144} m^3 e^2 \gamma$	$+\frac{807091}{12288} m^3 e^2 \gamma$	$+\frac{808711}{12288} m^3 e^2 \gamma$ (e)
$4D - F$	$+\frac{127483}{122880} m^5 \gamma$	$+\frac{456643}{122880} m^5 \gamma$	$+\frac{456643}{122880} m^5 \gamma$ (f)

Observations.

(a) Nos valeurs s'accordent avec celles de M. Plana, les corrections proposées par M. Delaunay paraissent donc inexactes.

(b) M. Delaunay adopte la rectification que nous avons fait subir au terme de M. Plana, quoiqu'il ait omis de le remarquer dans son tableau.

(c) Le terme donné par M. Plana coincide avec le mien en adoptant la formule de transformation corrigée par M. Adams. Son accord avec celui donné par M. Delaunay confirme son exactitude.

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* Il y a relativement à l'expression de la latitude une observation générale à faire ; j'avais adopté dans ma théorie le coefficient du terme dépendant de l'argument de la latitude, tel qu'il est donné par M. Plana. Mais M. Adams ayant rectifié une erreur parmi les quantités du 5e ordre dans l'expression de ce coefficient†, erreur qui influe sur tous les autres coefficients de l'expression de la latitude, il faut pour en tenir compte multiplier par le facteur $\left(1 + \frac{121}{256} m^4\right)$ tous les termes de M. Plana, avant de les comparer avec nos résultats et ceux de M. Delaunay. Cette simple correction fait disparaître, comme on peut s'en assurer, une grande partie des différences qu'on remarquait entre nos valeurs et celles de M. Plana, et les réduit relativement à l'expression de la latitude à un très petit nombre de termes.

† *Comptes Rendus*, 1862, 1er Sémestre (t. liv. No. 16), p. 876.

(d) M. Delaunay adopte la correction que j'ai faite au terme de M. Plana, quoiqu'il ne l'ait point rémarqué dans son tableau.

(e) Plusieurs combinaisons paraissent avoir été omises par MM. Plana et Delaunay dans la formation de ce terme.

(f) Le coefficient de notre théorie différait légèrement de celui de M. Delaunay, la rectification d'une erreur de calcul a ramené l'accord.

Valeur Inverse du Rayon Vecteur.

M. Delaunay n'ayant porté l'approximation dans l'expression de la valeur inverse du rayon vecteur que jusqu'aux quantités du 5^{e} ordre, et ses résultats se trouvant *à une seule* exception près parfaitement d'accord dans cette limite d'approximation, avec ceux de ses dévanciers, nous n'aurons de notre coté que de très courtes observations à présenter sur cet article.

Argument.	Terme de Plana.	Terme de Delaunay.	Théorie Analytique.
l	$-\frac{152129}{4608}\, m^4 e$	$-\frac{153389}{4608}\, m^4 e$	$-\frac{152129}{4608}\, m^4 e$

Observation.

Le coefficient du terme multiplié par cos l dans l'expression du rayon vecteur, se déduit du coefficient du terme correspondant ou du terme multiplié par sin l dans l'expression de la longitude, on ne conçoit donc pas la correction proposée par M. Delaunay relativement au coefficient de ce terme dans l'expression du rayon vecteur puisqu'il admet le coefficient du terme correspondant dans l'expression de la longitude, tel que le donne M. Plana.

J'ai reconnu en outre, que conformement à l'observation de M. Delaunay, les 3 termes suivants devaient être ajoutés à ceux que j'avais déjà signalés comme devant être supprimés dans l'expression de la valeur inverse du rayon vecteur donnée par M. Plana :

$$\text{Arg. } 2\,D - l - l' \qquad +\frac{35}{8}\, m\, e^3\, e'$$

$$\text{Arg. } 2\,D - l + l' \qquad -\frac{15}{8}\, m\, e^3\, e'$$

$$\text{Arg. } 2\,D - 2\,F \qquad +\frac{3}{32}\, m\, \gamma^4$$

Il résulte de la discussion précédente, 1°, Que quelques unes des corrections apportées par M. Delaunay aux résultats de M. Plana, même en se bornant à l'ordre d'approximation auquel il s'est arrêté paraissent inéxactes ; 2°, Que les différences

entre les coefficients des diverses inégalités lunaires donnés par ces deux géomètres et ceux qui se déduisent de notre théorie, se réduisent en définitive à un petit nombre de termes sans importance par leur valeur numérique, et qu'on ferait du reste aisément disparaître, soit en reprenant les calculs de M. Plana, ce qui est facile puis qu'il en a donné tout le détail dans son ouvrage, soit que M. Delaunay se décide lui-même à revoir quelques uns de ses résultats avant de les livrer à l'impression. Quoiqu'il en soit, on peut régarder comme un fait très important dans la théorie du système du monde, que cette coincidence à-peu-près complète des formules littérales qui déterminent *la longitude*, *la latitude*, et le *rayon vecteur* de la Lune, obtenues par trois méthodes absolument différentes et en portant l'approximation aussi loin que la pratique pouvait l'exiger. Ce résultat que les géomètres du dernier siècle n'avaient osé espérer, doit puissamment contribuer au perfectionnement des tables lunaires, et donner à leur construction toute la précision qu'ont acquise nos autres tables astronomiques.

Further Observations on Solar Spots.

By the Rev. F. Howlett.

It is with much pleasure that I submit to the indulgent attention of the Royal Astronomical Society a further account of observations of the Solar Spots; begging the Society to accept also the fruits, whatever they may be worth, of about eighteen months' additional honest endeavours to depict certain of those interesting phenomena which still continue to perplex the astronomical world, strongly prepossessed though some observers may be as to the theory of their character and import.

I have now the honour of laying before the Society a further series of drawings contained in about 64 sheets, comprising, first, some 128 whole disks on a scale throughout somewhat smaller than that usually employed hitherto by heliophotographers, and giving about 1 inch to $9' 37''$ of arc. The sheets exhibit, also, secondly, several hundreds of drawings of spots and groups of spots, on a scale varying from 1 inch to about $115''$, to the considerably larger scale of 1 inch to $62''$; which last is, perhaps, as convenient and instructive a size as could well be adopted for representing the details of the solar phenomena generally, in a daily record.

As I stated at our Monthly Meeting in December 1862, the amplification last mentioned may be readily and very effectively obtained by projecting the Sun's image in a duly darkened

chamber, upon a cardboard or other screen, placed 4 ft. 2 inches from the eye-piece of a telescope (of 3 feet 8 inches focal length and $3\frac{1}{4}$ inches aperture), the eye-piece magnifying about 80 times linear, and containing a kind of micrometer, or divided-glass-diaphragm, ruled off into $\frac{1}{100}$ths of an inch, each of the divisions of which is also seen distinctly projected upon the screen, and may be brought to correspond exactly with the several half-inches of a foot-rule carefully drawn upon the screen in ink.

By the above adjustment every $\frac{1}{16}$th of an inch would, of course, represent about 4″ of arc upon the projected solar disk.

When an eye-piece of 150 is employed, and the distance of the screen therefrom is adjusted to 3 feet 8 inches, every $\frac{1}{16}$th of an inch represents 2″ of arc only; which amplification is likewise attainable by employing a power of 120, and removing the screen to a distance of 5 feet 6 inches.

I have not yet estimated the value of still higher powers in connexion with the screen, though I occasionally scrutinise the spots by their aid.

A circle of about 18 inches in diameter, marked off into 360 degrees, is also drawn upon the screen, and a plumb-line hangs before it in order to insure the perpendicularity of the line joining the degrees 0° and 180° (or any other line parallel thereto), which represents the zenith and nadir points, for the time being, of the projected solar image.

When the screen is nicely and squarely adjusted (on an easel or otherwise) before the telescope, a fiducial line showing the course that is being pursued by a spot at any given hour across the disk, may be very approximately obtained by observing at what degree any spot enters, and at what degree also it quits, the circle, and referring this line, at leisure, by a parallel-ruler to the centre of the small drawing of the solar disk for the day; upon which drawing, however, the *positions* of the spots should be carefully dotted down immediately after noticing the course pursued by any one of them across the screen. The details of nuclei and penumbræ, &c. may of course then be drawn more leisurely. But a better plan is to throw any small, neatly defined spot precisely upon the central point of the circle on the screen, and observe where it cuts the circumference, which at once (not reckoning, however, the reversion of the image) gives the radial half of the fiducial line traversed by the spot. Despatch in noting down the positions of the spots is the more imperative the nearer it may be to the hour of noon that the observation is made; whilst at about an hour and a half after 6 A.M. and the same time before 6 P.M., the positions may be taken very deliberately — the line of junction of any two spots appearing then to be nearly stationary — though this line would be seen to retrograde before 6 A.M. and after 6 P.M. Indeed, since this

paper was commenced, I have been assured by an observer,* who informs me that he went in the year 1861 to high northern latitudes with the view of taking notes in connexion with astronomical subjects (chiefly solar), that he has, when within the Arctic Circle, actually seen this retrogradation going on during the whole period between 6 P.M. and 6 A.M.: the rate of retrogradation increasing or diminishing according as the hour was nearer to or further from the period sometimes called the "midnight sun." (See also the subject alluded to in the *Monthly Notices*, vol. xxi. No. 2, page 50, for December 14th, 1860.)

My observations, and some also of my drawings of the very conspicuous group of Solar Spots which passed off the disk on the evening of the 4th August, 1862, have already been honoured with a place in the *Monthly Notices* (vol. xxiii. No. 3), and the only reasons why I would wish to allude to them again on this occasion are these:—In the woodcut, fig. 6, p. 113, owing to some mistake, an actual notch in the Sun's normal or average margin is represented in the figure; whereas, in point of fact (and this is a very important difference), what I observed and described was only a notch caused, apparently, by an abnormal heaping up of facular photospheric matter to the north and south of the position occupied by the notch P.

Then, again, I must beg permission to demur to a statement made by Herrn Spoerer in their elaborate and careful paper in the *Astronomische Nachrichten* (No. 1402, column 147), wherein they assert that by mid-day on August 4th, 1862, the penumbra of the large spot (numbered by them 79†) "extended to the Sun's extreme edge." Whereas, owing in part probably to the very serene state of the atmosphere at my station of observation, I was enabled, at the hour above mentioned, to discern an unbroken streak of photosphere between the western edge of the penumbra and the Sun's limb; and as late even as 3.50 P.M. to estimate the breadth of this streak at about 2″.

By 6 P.M. indeed, and possibly at an earlier period, I observed that the nucleus of the great spot (79 of Prof. Spoerer, and ϱ, August 4th, in my record) had entirely disappeared, portions of penumbral matter, however, reaching completely to the Sun's extreme margin: and this has been the only occasion on which I could positively assert that I have seen the penumbral matter on the very edge of the Sun, with the exception of the interesting group π, which appeared upon the disk on the morning of February 18th, 1863, and included many patches

* Mr. J. Macnider, of No. 10 Norfolk Street, Strand.

† The diameter of this spot is reckoned by Prof. Spoerer at 4140 geographical miles, which space on the solar surface would subtend an angle of little more than 9″, whereas it was really at least 85″ in diameter when seen about the middle of the disk, as on July 29th, which is equivalent to fully 38,000 geographical miles.

of penumbra, and several strongly marked faculæ, and to which I shall have occasion to allude again in the present paper.

The usual preponderance of spots in the northern hemisphere has been as apparent as ever during the eighteen months last past. Out of the 128 disks now on the table it may, I think, be shown that a northern preponderance obtained on 80 days, a southern on 43, whilst on the remaining 5 days the spots were distributed pretty equally (more particularly as regards their energy) on each side of the Solar equator. Spots prevailed in the northern hemisphere during the whole of November and December 1861, as also during the whole of January, and first half of February 1862. My observations were suspended until about April 12th, 1862, when the spots were likewise in force in the north. They then went on alternating with tolerable impartiality (so far as I observed them) till about the last week in July 1862, when the northern preponderance was again apparent till the middle of August. During the whole of September, however, the south was chiefly in activity. For the first half of October the north again had the advantage; but during the next seven weeks I was unable to continue my record, having been absent from England; though, on my return home in the first week of December 1862, I found that the north was once more in the ascendant, and so it continued till about January 12th, 1863. Southern spots then prevailed till about February 18th. They then alternated (or seemed nearly evenly distributed at times) till March 17, after which northern spots maintained their ground till April 7th. The south then showed a superiority for about a week or so, then the north for a fortnight, and then the south once more resumed the preponderance, which it continued to hold up to May 19th, 1863, when the northern spots, though sufficiently important, were far excelled in interest and number by the southern ones; after which the northern spots altogether predominated till the end of May 1863. As, however, it is by no means an easy matter to determine always the precise line of the Sun's equator or of his parallels of latitude, I offer certain of the above particulars subject to correction.

During the past eighteen months the only day on which the Sun was observed by me to be devoid altogether of spots was the 9th April of the present year. I did not, however, scrutinise the disk very closely on the day in question, and certainly a small nucleated spot was visible on the 10th, about one minute from the Sun's preceding limb, and possibly, therefore, it may have been in existence on the day previous.

As a general rule spots have been tolerably plentiful on most days ever since the year of their estimated maximum in 1859; and their minimum period must not be expected before 1865 or 1866; reckoning, that is, from data collected by M.

Wolf, of Berne, and cited by Sir John Herschel in his *Outlines of Astronomy* (Ed. 1858), section 394[a].

There is a peculiar curvilinear arrangement of minute spots and patches of penumbræ, generally concentric, with a larger nucleated spot or group of spots, which I have not unfrequently noticed; and which, as well also as a highly interesting double, or sigmatoid curve, assumed sometimes by the little subordinate spots and patches, would seem to bear strongly upon the theory of cyclones upon the Sun's surface. These phenomena are recorded in sheets 73, April 30th, and 77, June 4th, 1862; in 99, Feb. 16th; 110, April 19th; 111, April 21st; and 115, May 11th, 13th, and 15th, 1863.

By the use of the screen I have obtained a far better insight than I could otherwise have had into the appearances and general disposition of those remarkable solar phenomena, the Faculæ. As is well known, these rarely or never occur in either high northern or southern latitudes, though they abound commonly in the zones occupied by the spots. Their forms are very varied, and often very fantastic. Sometimes they exist as small amorphous patches; sometimes they are stellate; at other times they assume a kind of reticulated or anastomosing appearance, or (as Profs. Spoerer observe) that of the circular lunar craters. Not unfrequently I have noticed them closely resembling the "merry-thought" of a bird, or even grotesque attenuated human figures. These appearances may be noted in the order in which they are mentioned in sheets 106, 122, 107, 109, 108, 114, &c.

The Faculæ are not only to be seen when near to the eastern or western limb of the Sun, but often also when quite on the central portions of the disk, where, if I interpret rightly certain appearances frequently presented on the screen, their existence may, amongst other forms which they are apt to assume, be detected as narrow, irregular, faintly luminous borderings, from about 4″ to 8″ in width, immediately surrounding *some*, though not all of the larger spots; and this luminosity appeared to me to be caused by an extra thickening of the photospheric matter by which the spots are surrounded, and by the absence, as a natural consequence, of that peculiar porous, curdled, and comparatively dusky appearance (caused in all probability by the interstices between the so-called "willow-leaves," or perhaps small aggregations of the willow-leaves of Mr. Nasmyth) which characterises the whole of the solar surface not actually occupied by the spots or faculæ. Moreover, I do not think that the faint borderings round the spots above alluded to are the effect of any instrumental or optical illusion, as I at first rather suspected.

A representation of their general appearance may be seen in sheet 99 of my record, under date Feb. 16th, 1863.

There is another point which may perhaps have been

noticed by other observers, but which I think well merits attention in any theorisings upon the constitution of the Sun: I allude to the frequently remarkable *persistency* of some of the smaller and more isolated spots, whether situated either more remote from or nearer to the Sun's equator. Whilst the contour and the details of the larger groups may be seen frequently to undergo a complete transformation during their passage across the disk, so that *hundreds of millions* of square miles of spots and penumbral matter are either entirely disposed of or so changed and re-arranged that it becomes impossible to recognise them under their new forms, it often happens, in the case of some of the smaller isolated spots, that one of not more, perhaps, than 5″ or 6″ in diameter (which small quantity, however, on the solar surface would imply a superficial area of from five to seven million square miles*) will be seen to maintain a nearly unaltered appearance for several consecutive days.

I have on previous occasions given in my humble adherence to the theory that the Solar Spots are cavities in the surface of our luminary, the nuclei being the most deeply sunk portions, the penumbra commonly shelving down to them on all sides from the external photosphere; though at the same time I had generally found that the penumbræ possessed only an exceedingly slight amount of depression within the solar surface. Very palpable evidence of this latter fact was afforded, as it seemed to me, by the fine group π of the 18th Feb. 1863, already mentioned (sheet 99). The group in question consisted of two somewhat contiguous large spots, accompanied, as it afterwards proved, by many faculæ and numerous smaller spots, and detached patches of penumbra. But so broadly conspicuous (as seen projected on the screen) were the nuclei of both the contiguous large spots, and so completely devoid was the most westerly nucleus of *any measure* of penumbra on its eastern (following) edge, that I not only was more strongly convinced than ever of the extreme shallowness of the penumbral depressions, but I even for a while wondered whether, after all, they and the nuclei could be depressions at all!

The two nuclei were distant, respectively, about 15″ and 30″ from the Sun's limb at the moment when I experienced these doubts; but when the group was well advanced upon the disk (as it was by Feb. 21, when I next observed it), it was evident that I could not have seen any penumbra upon the eastern side of the great westerly nucleus, for the simple reason that it proved to be devoid of any in that direction;

* 1″ subtends 450 miles. Therefore,

$(5'' \times 450)^2 = 5{,}073{,}750$ square miles

and, $(6 \times 450)^2 = 7{,}290{,}000$ „ „

whilst conversely the easterly large spot proved to have but comparatively little penumbra upon its western (preceding) side, and what little it had would doubtless have been still further diminished to sight on the 18th by the effect of foreshortening, as first described by Dr. Wilson. It was on this same day (Feb. 18th, 1863) that I observed, for the second time only within my experience, that the penumbral matter in straggling connexion with the most easterly spot of group π extended absolutely to the Sun's edge, and surrounded, evidently, the northern extremity of a conspicuous mass of faculæ which extended along the limb of the Sun; many other facular streaks also occurring in the neighbourhood of the spots, and extending uninterruptedly to the great group lettered ϱ, which lay about $2' 25''$ to the north.

A group possessing many features in common with the one just described as group π came upon the disk on the morning of April 12th, 1863, and in neither of the two principal spots was I able to trace much appearance of penumbra on the eastern side of their respective nuclei; but the details of the group had suffered such extensive changes by April 15th that the appearances they exhibited, when well on the disk at the latter date, could by no means be appealed to for evidence as to what might have been the disposition of the various nuclei and penumbræ on the 12th of the same month. I had observed these changes going on during the interim, but was unable to secure drawings of them. I particularly noticed, however, that the most westerly spot, lettered η 5, had shrunk to about one-fourth of the magnitude it had possessed on entering the disk.

Since the Meeting in May last I have observed and drawn an unusually interesting group, as shown in sheet 115, under date May 11th, 1863, and letter ξ of my record. Both the principal spot, as well as from twenty to thirty much smaller subordinate ones, appeared to be obeying some strongly vorticose impulse during this period of their development. Starting either from a small group of faint penumbral patches situated about $45''$ to the east, or more probably, as I thought, from a more considerable spot about $18''$ in length, lying $12''$ or so to the north-east of the principal spot, they had formed around this latter for fully half the circumference of a circle, adopting a curious, bifurcating, diverging course, bearing no inconsiderable resemblance to the spiral structure of some of the great nebulous clusters of stars, as revealed in Lord Rosse's gigantic reflecting telescope.

I did not see the group ξ again until the morning of May 13th, when its whole appearance was as much changed as could well be conceived. The small detached eastern group above alluded to had developed into a large elongated trifid connected spot, fully $1' 17''$ in length from north-west to south-

east, and containing three or four easily-discerned nuclei; whilst the other series of small spots (which had presented, two days previously, that peculiar spiral arrangement) were replaced also by a large, very irregular confluent group, about 1′ 30″ in length, likewise extending from north-west to south-east, and comprising six or eight small nuclei, which were represented by three very much larger ones on the day following (May 14th), when I last observed them.

Moreover, on May 13th, a line of faint and somewhat remotely separated penumbral specks swept through the midst of group ξ in a delicate sigmatoid curve (very similar in its character to the sigmatoid curve observed by me on April 30, 1862), which appeared to indicate the existence of some common and extensive influence then at work throughout the whole system of the aggregate group, and which curve may also be seen to bifurcate at a point not far from equidistant between the principal spot and the north-west extremity of the trifid easterly group.

It is also, perhaps, worthy of note that, whilst from these and some other of my drawings it is apparent that the nuclei sometimes preceded the formation of their penumbræ, at other times the reverse was the case; for I presume that the illustrious Kirchhoff would by no means wish to assert that the former case always holds good, as one might almost seem to gather from a passage (p. 27) of Prof. Roscoe's translation of Kirchhoff's *Researches on the Solar Spectrum and the Spectra of the Chemical Elements.*

I have only one more subject to mention, and that is, that I hope some one else besides myself took notice of and depicted, or, better still, secured a photograph of, a most curious phantom-looking group of spots which, at 1 P.M. on the 4th January of this present year, exhibited an appearance so wonderfully like a human skeleton, that, in a less superstitious age than the nineteenth century, its portentous shape might easily have raised considerable apprehension in the minds of the multitude.

Being Sunday when this was observed, and being much occupied with the more immediate duties of my profession, I did not draw the group with micrometric correctness, but simply took a rough sketch of the phantom, which subtended about 5′ 40″ of arc, or 153,000 miles, and respecting which (as I observed lately to Admiral Manners) I am really not aware that any love for the marvellous induced me to exaggerate in any degree the singularity of its proportions.

Sheet 96 exhibits this group as it appeared, when much altered, on Jan. 7th.

On Eyepieces.

(*Extract of a Letter from the Rev. W. R. Dawes.*)

I have seen enough of the three eyepieces you sent to report upon them with some confidence.

1st. The *Airy* (marked with pencil 271).* I cannot believe this to be a fair representation of the proper combination of curves pointed out by Mr. Airy. The field is by no means large, and towards the edge there is a very decided red fringe. It is vastly inferior to any ordinary astronomical Huyghenian eyepiece I possess, as constructed by Dollond, Ramsden, and Tulley. The angular subtense of the diaphragm is 37° 57′, and of that small angle not more than about 25° are good.

2. The *Kellner* (as it professes to be) is also an unfair specimen of his construction, the diaphragm being *considerably too small.* The angular subtense is only 37°·35; but the distinctness at the very edge of the field is scarcely less than in the centre, and gives the impression that the angular subtense of the diaphragm might be advantageously enlarged to at least 48° or 50°.

3. The *Aplanatic* has a very large field, and is pleasantly *achromatic* to the edge; but the exterior 4° or 5° of the angular subtense of the diaphragm (which = 59°·47) are far from distinct; and I doubt whether much more than 50° out of the whole subtense would be sufficiently so. To determine this, however, with exactness, would require careful observations on a fine night; and I have not been able to spare the *fine* starlight for the purpose. This eyepiece has a double ghost when a bright object is in the field.

An ordinary *Ramsden* Huyghenian which I have has a perfectly distinct and achromatic angular subtense of 48°.

In a *Kellner's* eyepiece, *made by himself*, the angular subtense = 49°·56: admirably distinct and achromatic to the edge.

In a *Dollond* Huyghenian, the angular subtense = 46°·46: nearly perfect throughout.

In a *Tulley* Huyghenian, the angular subtense = 51°·84: extremely fine in colour and distinctness.

These, you will see, are scarcely, if at all, inferior to the "*Aplanatic*," and have far less of ghostly appendages.

Hopefield Observatory, Haddenham, Thame,
April 9, 1863.

* The Astronomer Royal remarks that he has never seen this eyepiece, and knows nothing about it.—Ed.

LIST OF PRESENTS

RECEIVED DURING THE SESSION OF 1862–63,

AND OF

BOOKS PURCHASED WITH THE TURNOR FUND

DURING THE SAME PERIOD,

FORMING

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